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**From:** Tonnesen, Gail [Tonnesen.Gail@epa.gov]  
**Sent:** 6/30/2015 6:07:46 PM  
**To:** huys@clarkcountynv.gov; Paul.Fransioli@ClarkCountyNV.gov; Hoag, Katherine [Hoag.Katherine@epa.gov]; Bohnenkamp, Carol [Bohnenkamp.Carol@epa.gov]; Bohning, Scott [Bohning.Scott@epa.gov]; Payton, Richard [Payton.Richard@epa.gov]; pfister@ucar.edu; brad.pierce@noaa.gov; Patrick.Reddy@dphe.state.co.us; andrew.o.langford@noaa.gov; Matichuk, Rebecca [Matichuk.Rebecca@epa.gov]; irina.petro@noaa.gov; Evangelista, Mark [Evangelista.Mark@epa.gov]; audra.mcclure@noaa.gov; Frank Forsgren [fforsgre@ndep.nv.gov]  
**Subject:** FW: Recent intrusion events  
**Attachments:** mloF11H1211hourly.pdf; nwrF11H1211hourly.pdf

Forwarding plots from Irina, and I also uploaded these to the sharepoint site.

Thanks,  
Gail  
303-312-6113

**From:** Irina Petropavlovskikh - NOAA Affiliate [mailto:irina.petro@noaa.gov]  
**Sent:** Tuesday, June 30, 2015 10:27 AM  
**To:** Gabriele Pfister; Tonnesen, Gail; Patrick Cullis - NOAA Affiliate  
**Subject:** Fwd: Recent intrusion events

Here is an email with attached plots from Geoff Dutton for MLO and Niwot Ridge sites.  
Please forward to others

Irina

----- Forwarded message -----

**From:** **Geoff Dutton - NOAA Affiliate** <geoff.dutton@noaa.gov>  
**Date:** Wed, Jun 10, 2015 at 1:41 PM  
**Subject:** Re: Recent intrusion events  
**To:** Irina Petropavlovskikh - NOAA Affiliate <irina.petro@noaa.gov>, Audra McClure - NOAA Affiliate <audra.mcclure@noaa.gov>

Hi Irena and Audra,

I've tried to find stratospheric influenced air at NWR for Pat before, unfortunately without much luck. CFC-11 and halon-1211 are good tracers since their primary loss is in the stratosphere and the GC measures them well. The lifetime of N2O is about a factor of 2 greater than CFC-11 and a factor of 5 greater than halon-1211, thus it is depleted at a higher altitude in the stratosphere. To see a change in N2O as well as CFC-11 and halon-1211 the intrusion would need to come from a higher altitude.

I've attached two figures (note the y-axis range is the same in both figures). The first shows several intrusions measured at MLO in 2006. The largest has CFC-11 down about 4 ppt (1.6%) from typical free tropospheric measurements (halon is about 2% depleted). The second figure is from NWR these past couple of weeks. You'll notice typical pollution events but no depleted measurements.

Maybe C1 is not quite high enough on the Niwot Ridge to see these events? What does the O3 data look like?

Geoff

On Tue, Jun 9, 2015 at 6:40 PM, Irina Petropavlovskikh - NOAA Affiliate <irina.petro@noaa.gov> wrote:

Hi Geoff

See discussion below

Do you have any N2O or CFC11 data for June 1- 9 at the Niwot Ridge to see if there was a stratospheric intrusion on June 4 and 7th

Cheers,

Irina

----- Forwarded message -----

From: **Reddy - CDPHE, Patrick** <patrick.reddy@state.co.us>

Date: Tue, Jun 9, 2015 at 12:34 PM

Subject: Recent intrusion events

To: "Tonnesen, Gail" <tonnesen.gail@epa.gov>, "payton.richard@epa.gov" <payton.richard@epa.gov>, Brad Pierce <brad.pierce@noaa.gov>, "Pierce", 'GORDON' <Gordon.Pierce@state.co.us>, Andrew Langford-NOAA Federal <andrew.o.langford@noaa.gov>, Irina Petropavlovskikh <irina.petro@noaa.gov>, Audra McClure - NOAA Affiliate <audra.mcclure@noaa.gov>, Christoph Senff <Christoph.Senff@noaa.gov>, "pfister@ucar.edu" <pfister@ucar.edu>, Scott Landes - CDPHE <scott.landes@state.co.us>, Gregory Harshfield - CDPHE <gregory.harshfield@state.co.us>, "huys@clarkcountynv.gov" <huys@clarkcountynv.gov>, "Duncan, Bryan N. (GSFC-6140)" <bryan.n.duncan@nasa.gov>, "OTT, LESLEY E. (GSFC-6101)" <lesley.e.ott@nasa.gov>

Hi all,

We have had several days with possible stratospheric O3 intrusion influences on surface concentrations in Colorado and other western states. A closed upper low around California slowly moved east and weakened, leaving an elongate zone of lowered tropopause heights, low pressure, and elevated free troposphere and total column O3 stretching from Nevada to Colorado and Wyoming where it has been affecting surface O3 for a number of days.

To complicate matters, we are in the summer anthropogenic O3 season, and we are clearly seeing contributions from anthropogenic O3 along Colorado's Front Range. To further complicate matters, there is evidence that thunderstorms have enhanced the transport or mixing of stratospheric O3 to the surface and that thunderstorms have also lowered surface O3, even while free tropospheric O3 concentrations may have shown the effects of the intrusions. This period highlights the need to use all of the tools we have to sort out the contributions of local anthropogenic O3, Asian transport, distant biomass burning, and stratospheric intrusions. In addition, with thermally-driven upslope along the Front Range and possible mountain-plains solenoids during the last few days, we need to determine whether elevated layers seen in ozonesonde or lidar data are from local sources or intrusions or both.

On June 4, we had high concentrations on the plains around Denver and at our 12,500-foot MSL Mines Peak site. Mines Peak concentrations were "cruising" at 69 to 73 ppb for the first half of the day (likely intrusion O3 background?) and then abruptly climbed to 82 ppb around 5 PM MDT. This peak period was probably associated with thermally-driven upslope adding an increment of Denver anthropogenic O3 (an extra 10 ppb?). Back trajectories for this site and time lead back to Denver. Total column O3 maps show the low over the West Coast, but do not reveal the likely streamers of stratospheric air in the troposphere in the southwesterly flow aloft out ahead of this system. I have not yet had a chance to look at all the products (IDV, RAAQMs, etc.) for this day,

At the same time, Chatfield climbed to 80 ppb around 2PM MST under upslope and Denver Cyclone conditions. Thunderstorms formed to the east. Radar data shows that an outflow boundary from these storms hit Chatfield around 3 pm, and this dropped O3 to 56 ppb by 5 PM MST. Winds behind the outflow boundary were from the southeast. So entrainment of stratospheric O3 above

the evolving PBL may have enhanced the surface concentrations along the plains that may already have been high because of normal summer processes acting on local sources.

I have attached relevant plots for June 4. Intrusion effects likely continued in the multi-state region on June 5 and 6, but I will skip ahead to June 7 when a complex west-east pattern of residual high total column O<sub>3</sub>, high O<sub>3</sub> concentrations aloft, high and low satellite water vapor, and thunderstorms was draped across northern Colorado. This pattern was an extension of the remnants of the upper low and seemed to be causing high O<sub>3</sub> at the surface from Nevada and Utah to Colorado and southern Wyoming. Attempts to look for streamers or laminae of high IPV associated with intrusions in the area have so far not yielded much success. This may be because of the age of the system and confounding effects of storms on IPV.

During the early evening hours on June 7 an east-west oriented outflow boundary from storms near Ft. Collins, Greeley, and the Wyoming border propagated to the south. Before it generated a new line of storms to the south, it passed over our Aurora East monitor, briefly raising O<sub>3</sub> there to 73 to 87 ppb for 3 hours. So, in this case, storms seem to have increased the transport/mixing of likely stratospheric O<sub>3</sub> to the surface.

I had O<sub>3</sub> forecast duties on Sunday and called for an exceedance along the Front Range for Monday. Under classic thermally-driven upslope conditions, we saw 8-hour concentrations reach 76 ppb at Chatfield, RFLAT, and NREL on June 8. There may have been a mountain-plains solenoid, and it is possible that a residual layer of anthropogenic O<sub>3</sub> is "mixed in" with residual stratospheric O<sub>3</sub> in the free troposphere (last night and this morning - June 9). The Niwot Ridge data for June 8 has a late-day bump in O<sub>3</sub> that may be associated with the arrival of urban upslope. I have attached a few more plots.

With many things happening at once, I think this period points to the need for models to help us sort out the influence of stratospheric O<sub>3</sub> across the region.

Regards,

Pat

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Patrick J. Reddy  
Senior Air Quality Meteorologist  
Modeling, Meteorology, and Emissions Inventory Unit  
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